

CLAIMS

What is claimed is:

1. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a reservoir for containing a liquid, the liquid having a surface that defines a space above the surface, the container also having a space outlet that connects the space to an exterior of the container;

a scrubbing cylinder positioned in the space and having a top, a fan wheel space positioned at the top, an inside wall, an open bottom end positioned above the surface of the liquid, and a centrifugal scrubbing space extending from the fan wheel space downward along the inside wall;

an inlet tube having an inlet positioned on the exterior of the container and an outlet positioned at the fan wheel space to provide a passage way that allows the gas to flow from the exterior of the container through the inlet tube, the fan wheel space, the centrifugal scrubbing space, over the surface of the liquid, through the space in the container, and out the space outlet;

a pump having an inlet connected to the reservoir and an outlet positioned to pump the liquid to the centrifugal scrubbing space to allow the liquid to circulate from the reservoir, through the pump, to the centrifugal scrubbing space, and back to the reservoir; and

a fan wheel positioned in the fan wheel space and mounted to a shaft having a motor for rotating the shaft and the fan wheel, the fan wheel pumping the gas through the passage way and discharging the gas tangentially at a high velocity in the centrifugal scrubbing space, to rotate the liquid with the gas in the centrifugal scrubbing space, to impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

2. The scrubber of claim 1, wherein the shaft extends up into the space in the container, the shaft having a second fan wheel attached thereto to increase a rate of flow through the scrubber and to increase a rotational rate of gas in the space in the container.

3. The scrubber of claim 1, wherein the space outlet of the container has a top wall and an outlet opening that is centrally positioned in the top wall, the outlet opening having a diameter that is smaller than a diameter of the top wall.
4. The scrubber of claim 1, wherein the open bottom end of the scrubbing cylinder has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the centrifugal scrubbing space to flow downward in a rotational manner and to impact the surface of the liquid.
5. The scrubber of claim 1, wherein the motor is mounted in the inlet tube.
6. The scrubber of claim 1, wherein the outlet of the pump has a filter.
7. The scrubber of claim 1, wherein the fan wheel has blades that have extensions that extend down into the centrifugal scrubbing space.

8. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a reservoir for containing a liquid, the liquid having a surface that defines a space above the surface, the container also having a space outlet that connects the space to an exterior of the container;

a scrubbing cylinder positioned in the space and having a top, a fan wheel space positioned at the top, an inside wall, an open bottom end positioned above the surface of the liquid, and a centrifugal scrubbing space extending from the fan wheel space downward along the inside wall;

an inlet tube having an inlet positioned on the exterior of the container and an outlet positioned at the fan wheel space to provide a passage way that allows the gas to flow from the exterior of the container through the inlet tube, the fan wheel space, the centrifugal scrubbing space, over the surface of the liquid, through the space in the container, and out the space outlet;

a fan wheel positioned in the fan wheel space and mounted to a shaft having a motor for rotating the shaft and the fan wheel, the fan wheel pumping the gas through the passage way; and

a pump having an inlet connected to the reservoir and an outlet positioned to pump the liquid to the fan wheel space to allow the liquid to circulate from the reservoir, through the pump, to the fan wheel, to the centrifugal scrubbing space, and back to the reservoir, and to allow the rotating fan wheel to discharge the gas and the liquid tangentially at a high velocity in the centrifugal scrubbing space, to rotate the liquid with the gas in the centrifugal scrubbing space, to impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

9. The scrubber of claim 8, wherein the pump comprises a cone-shaped case having a larger outlet end positioned at and attached to the fan wheel to rotate therewith and having a smaller inlet end positioned below the surface of the liquid to receive the liquid and centrifugally discharge the liquid out of the larger outlet end to the fan wheel.

10. The scrubber of claim 8, wherein the pump comprises a non-rotating pumping case having an inlet end positioned below the surface of the liquid, an outlet end positioned proximate

the fan wheel, and an impeller attached to the shaft to rotate therewith, the shaft being positioned in the inlet end of the pumping case to pump the liquid through the outlet end to the fan wheel.

11. The scrubber of claim 8, wherein the shaft extends up into the space in the container, the shaft having a second fan wheel attached thereto to increase a rate of flow through the scrubber and to increase a rotational rate of gas in the space in the container.

12. The scrubber of claim 8, wherein the space outlet of the container has a top wall and an outlet opening that is centrally positioned in the top wall, the outlet opening having a diameter that is smaller than a diameter of the top wall.

13. The scrubber of claim 8, wherein the open bottom end of the scrubbing cylinder has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the centrifugal scrubbing space to flow downward in a rotational manner and to impact the surface of the liquid.

14. The scrubber of claim 8, wherein the motor is mounted in the inlet tube.

15. The scrubber of claim 8, wherein the outlet of the pump has a filter.

16. The scrubber of claim 8, wherein the fan wheel has blades that have extensions that extend down into the centrifugal scrubbing space.

17. The scrubber of claim 8, wherein the fan wheel comprises a base hub having fan blades and protrusions that are vertically positioned to define a liquid receiving space between the protrusions and the shaft, an inlet scrubbing space located between the protrusions and the fan blades, and wherein the outlet of the pump is positioned in the liquid receiving space to allow the protrusions to discharge the liquid at a high velocity through the inlet scrubbing space to additionally scrub the gas.

18. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a top, a bottom wall, a side wall, a container outlet at the top, and a reservoir for containing a liquid, the liquid having a surface that defines a cyclone space between the surface, the side wall, and the container outlet;

an inlet cylinder having an inlet attached to a centrally positioned opening in the bottom wall, the inlet cylinder being vertically mounted and extending up through the reservoir with an inlet cylinder outlet positioned above the surface;

a scrubbing cylinder vertically mounted and centrally positioned in the cyclone space and encircling the container outlet, the scrubbing cylinder having a top, a closed end at the top that defines a fan wheel space between the inlet cylinder outlet and the closed end, and a bottom outlet positioned below the inlet cylinder outlet and above the surface of the liquid, and defining a scrubbing space between an interior of the scrubbing cylinder and an exterior of the inlet cylinder, to provide a passage way that allows the gas to flow from the exterior of the container through the inlet cylinder, the fan wheel space, the scrubbing space, out the bottom outlet, over the surface of the liquid, through the cyclone space, and out the container outlet;

a pump having a pump inlet connected to the reservoir and a pump outlet connected to the scrubbing space, for circulating liquid from the reservoir, through the pump, the scrubbing space, and out the bottom outlet to the reservoir; and

a fan wheel having fan blades and connected to a shaft having a motor to rotate the fan wheel, the fan wheel being positioned in the fan wheel space to pump the gas through the passage way, to discharge the gas tangentially at a high rotational rate in the scrubbing space, to rotate the liquid with the gas in the scrubbing space, and to impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

19. The scrubber of claim 18, wherein the shaft extends up into the cyclone space and has a second fan wheel attached thereto to increase a rate of flow through the scrubber and to increase the rotational rate of gas in the cyclone space.

20. The scrubber of claim 18, wherein the container outlet includes a top wall having a centrally positioned outlet opening that has a diameter that is smaller than a diameter of the top wall.
21. The scrubber of claim 18, wherein the bottom outlet of the scrubbing cylinder has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the scrubbing space to flow downward in a rotational manner and to impact the surface of the liquid.
22. The scrubber of claim 18, wherein the pump outlet has a filter.
23. The scrubber of claim 18, wherein the fan blades of the fan wheel have extensions that extend down into the scrubbing space.

24. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a top, a container outlet located at the top, a bottom wall, and a side wall that define a reservoir for containing the liquid, the liquid having a surface that defines a cyclone space between the surface, the side wall, and the container outlet;

a deflector wall mounted above the container outlet and having a vertically mounted, centrally positioned inlet cylinder with an inlet cylinder inlet positioned above the deflector wall and external to the container and an inlet cylinder outlet located below the inlet cylinder inlet;

a scrubbing cylinder vertically mounted and having a scrubbing cylinder inlet encircling the inlet cylinder outlet and centrally attached to a bottom of the deflector wall, the scrubbing cylinder extending down centrally through the container outlet and into the cyclone space with a scrubbing cylinder outlet positioned above the surface, the scrubbing cylinder providing a fan wheel space at a top of the scrubbing cylinder inlet proximate the inlet cylinder outlet and forming a scrubbing space on an interior of the scrubbing cylinder that provides a passage way that allows a gas to flow from an exterior of the container through the inlet cylinder, the fan wheel space, the scrubbing space, out the scrubbing cylinder outlet, over the surface, through the cyclone space, and out the container outlet below the deflector wall;

a pump having a pump inlet connected to the reservoir and a pump outlet positioned at the fan wheel space, to circulate the liquid from the reservoir through the pump and the fan wheel space, the scrubbing space, and out the scrubbing cylinder outlet back to the reservoir; and

a fan wheel having fan blades and connected to a shaft having a motor to rotate the fan wheel, the fan wheel being positioned in the fan wheel space to pump the gas through the passage way and to discharge the gas and the liquid tangentially at a high rotational rate in the scrubbing space, to rotate the liquid with the gas, to impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

25. The scrubber of claim 24, wherein the pump comprises of a cone-shaped case having a larger outlet end positioned at and attached to the fan wheel to rotate therewith and a smaller

inlet end positioned below the surface of the liquid to receive the liquid and centrifugally discharge the liquid out of the larger outlet end to the fan wheel.

26. The scrubber of claim 24, wherein the pump comprises of a non-rotating pumping case having an inlet end positioned below the surface of the liquid, an outlet end positioned proximate the fan wheel, and an impeller attached to the shaft to rotate therewith, the impeller being positioned in the inlet end of the case to pump the liquid through the outlet end to the fan wheel.

27. The scrubber of claim 24, wherein the scrubbing cylinder outlet has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the scrubbing space to flow downward in a rotational manner and to impact the surface.

28. The scrubber of claim 24, wherein the pump outlet includes a filter.

29. The scrubber of claim 24, wherein the fan blades of the fan wheel have extensions that extend down into the scrubbing space.

30. The scrubber of claim 24, wherein the fan wheel includes a base hub having vertically positioned protrusions providing a liquid receiving space between the protrusions and the shaft and an inlet scrubbing space between the protrusions and the fan blades of the fan wheel, with the pump outlet positioned in the liquid receiving space to allow the protrusions to discharge the liquid at a high velocity through the scrubbing space to additionally scrub the gas.

31. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a top, a container outlet at the top, a bottom wall, and a side wall providing a first reservoir for containing a liquid, the liquid having a surface forming a cyclone space between the surface, the side wall, and the container outlet;

an inlet cylinder vertically mounted in and extending up through the reservoir, the inlet cylinder having an inlet cylinder inlet centrally positioned in the bottom wall, and an inlet cylinder outlet positioned above the surface of the liquid;

a scrubbing cylinder vertically mounted and centrally positioned in the cyclone space and encircling the inlet cylinder outlet, the scrubbing cylinder having a top, a bottom, a closed end at the top forming a fan wheel space between the inlet cylinder outlet and the closed end, and a scrubbing cylinder outlet at the bottom positioned below the inlet cylinder outlet and above the surface of the liquid, and defining a scrubbing space between an interior of the scrubbing cylinder and an exterior of the inlet cylinder, to provide a passage way that allows a gas to flow from outside of the container through the inlet cylinder, the fan wheel space, the scrubbing space, out the scrubbing cylinder outlet, over the surface of the liquid, through the cyclone space, and out the container outlet;

a pump having a pump inlet connected to the first reservoir and a pump outlet connected to a second reservoir, the second reservoir being positioned in the inlet cylinder, and the pump pumping liquid from the first reservoir to the second reservoir and providing a second liquid surface in the second reservoir;

a fan wheel having fan blades and a vertically mounted, cone-shaped pumping case connected to a shaft and a motor to rotate the fan wheel, the fan wheel being positioned in the fan wheel space, the pumping case having a bottom smaller inlet end positioned below the second liquid surface to allow liquid to gravitate into the pumping case, and a top larger outlet end positioned at a mid-section of the fan blades; and

the pumping case pumping liquid from the second reservoir to the fan blades to allow the liquid to flow from the first reservoir, through the pump, the second reservoir, the pumping case, the fan wheel, the scrubbing space, and back to the first reservoir, and the rotating fan blades

pumping the gas through the passage way and discharging the gas and the liquid tangentially at a high rotational rate in the scrubbing space, to rotate the liquid with the gas in the scrubbing space, to impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

32. The scrubber of claim 31, wherein the shaft extends up into the cyclone space and has a second fan wheel attached thereto to increase a rate of flow through the scrubber and to increase a rotational rate of gas in the cyclone space.

33. The scrubber of claim 31, wherein the container outlet has a top wall with a centrally positioned outlet opening having a diameter that is smaller than a diameter of the top wall.

34. The scrubber of claim 31, wherein the scrubbing cylinder outlet has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the scrubbing space to flow downward in a rotational manner and to impact the surface of the liquid.

35. The scrubber of claim 31, wherein the fan blades of the fan wheel have extensions that extend down into the scrubbing space.

36. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a top, a container outlet at the top, a bottom wall, and a side wall providing a first reservoir for containing a liquid, the liquid having a first surface forming a cyclone space between the first surface, the side wall, and the container outlet;

an inlet cylinder vertically mounted and extending up through the reservoir, the inlet cylinder having a bottom, an inlet cylinder inlet at the bottom and attached to a centrally positioned opening in the bottom wall, a top, and an inlet cylinder outlet positioned at the top above the surface of the liquid;

a second reservoir positioned in the inlet cylinder and connected to the first reservoir to receive liquid from the first reservoir and form a second surface;

a scrubbing cylinder vertically mounted and centrally positioned in the cyclone space and encircling the inlet cylinder outlet, the scrubbing cylinder having a top, a closed end at the top that forms a fan wheel space between the inlet cylinder outlet and the closed end, a bottom, and a scrubbing cylinder outlet positioned below the inlet cylinder outlet and above the first surface, thereby defining a scrubbing space between an interior of the scrubbing cylinder and an exterior of the inlet cylinder, to provide a passage way that allows a gas to flow from outside of the container through the inlet cylinder, the fan wheel space, the scrubbing space, out the scrubbing cylinder outlet, over the first surface, through the cyclone space, and out the container outlet;

a fan wheel having fan blades and a vertically mounted, cone-shaped pumping case connected to a shaft and a motor to rotate the fan wheel, the fan wheel being positioned in the fan wheel space, and the pumping case having a bottom smaller inlet end positioned in the second reservoir below the second surface, to allow liquid to gravitate into the pumping case, and a top larger outlet end positioned at the fan blades; and

the pumping case pumping liquid from the second reservoir to the fan blades to allow the liquid to flow from the first reservoir, through the pump, the second reservoir, the pumping case, the fan wheel, the scrubbing space, and back to the first reservoir, and the fan blades pumping the gas through the passage way and discharging the gas and the liquid tangentially at a high rotational rate in the scrubbing space, to rotate the liquid with the gas in the scrubbing space, to

impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

37. The scrubber of claim 36, wherein the shaft extends up into the cyclone space and has a second fan wheel attached thereto to increase a rate of flow through the scrubber and to increase a rotational rate of gas in the cyclone space.

38. The scrubber of claim 36, wherein the container outlet has a top wall with a centrally positioned outlet opening having a diameter that is smaller than a diameter of the top wall.

39. The scrubber of claim 36, wherein the scrubbing cylinder outlet has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the scrubbing space to flow downward in a rotational manner and to impact the first surface.

40. The scrubber of claim 36, wherein the fan blades of the fan wheel have extensions that extend down into the scrubbing space.

41. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a top, a container outlet at the top, a bottom wall, and a side wall providing a reservoir for containing a liquid, the liquid having a first surface forming a cyclone space between the surface, the side wall, and the container outlet;

an inlet cylinder vertically mounted and extending up through the reservoir, the inlet cylinder having a bottom, an inlet cylinder inlet at the bottom and attached to a centrally positioned opening in the bottom wall, a top, and an inlet cylinder outlet at the top positioned above the first surface;

a non-rotatable pumping case positioned in the inlet cylinder and having a pumping case inlet connected to the reservoir to receive liquid from the reservoir;

a scrubbing cylinder vertically mounted and centrally positioned in the cyclone space and encircling the inlet cylinder outlet, the scrubbing cylinder having a top, a closed end at the top that defines a fan wheel space between the inlet cylinder outlet and the closed end, a bottom, and a scrubbing cylinder outlet positioned below the inlet cylinder outlet and above the first surface, thereby defining a scrubbing space between an interior of the scrubbing cylinder and an exterior of the inlet cylinder, to provide a passage way that allows a gas to flow from outside of the container through the inlet cylinder, the fan wheel space, the scrubbing space, out the scrubbing cylinder outlet, over the first surface, through the cyclone space, and out the container outlet;

a fan wheel having fan blades connected to a shaft and a motor to rotate the fan wheel, the fan wheel being positioned in the fan wheel space;

a pump impeller positioned proximate the pumping case inlet and connected to the shaft to rotate therewith and pump liquid up and out of a pump case outlet that is positioned at the fan blades to allow liquid to circulate from the reservoir, through the pumping case, the fan wheel space, the scrubbing space, and back to the reservoir; and

the rotating fan wheel receiving the liquid from the pump case outlet and pumping the gas through the passage way and discharging the gas and the liquid tangentially at a high rotational rate in the scrubbing space, to rotate the liquid with the gas in the scrubbing space, to impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

42. The scrubber of claim 41, wherein the shaft extends up into the cyclone space and has a second fan wheel attached thereto to increase a rate of flow through the scrubber and to increase a rotational rate of gas in the cyclone space.
43. The scrubber of claim 41, wherein the container outlet has a top wall with a centrally positioned outlet opening having a diameter that is smaller than a diameter of the top wall.
44. The scrubber of claim 41, wherein the scrubbing cylinder outlet has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the scrubbing space to flow downward in a rotational manner and to impact the first surface.
45. The scrubber of claim 41, wherein the motor is mounted in the inlet cylinder.
46. The scrubber of claim 41, wherein the fan blades of the fan wheel have extensions that extend down into the scrubbing space.

47. A gas scrubber for scrubbing a gas by using a liquid to remove particulate and absorb gas molecules from the gas, comprising:

a container having a top, a container outlet at the top, a bottom wall, and a side wall providing a reservoir for containing a liquid, the liquid having a surface forming a cyclone space between the surface, the side wall, and the container outlet;

a deflector wall mounted above the container outlet and having a vertically mounted inlet cylinder with a top, a bottom, an inlet cylinder inlet at the top, an inlet cylinder outlet at the bottom, a centrally positioned inlet opening attached to the inlet cylinder outlet, and the inlet cylinder inlet being positioned above the deflector wall and external to the container;

a scrubbing cylinder vertically mounted and extending down centrally through the container outlet into the cyclone space, the scrubbing cylinder having a top, a scrubbing cylinder inlet at the top, encircling the inlet cylinder outlet, and centrally attached to a bottom of the deflector wall, a scrubbing cylinder outlet positioned above the surface of the liquid, a fan wheel space at the top of the scrubbing cylinder inlet end proximate the inlet cylinder outlet and forming a scrubbing space on an interior of the scrubbing cylinder that provides a passage way that allows a gas to flow from outside of the container through the inlet cylinder, the fan wheel space, the scrubbing space, out the scrubbing cylinder outlet, over the surface of the liquid, through the cyclone space, and out the container outlet below the deflector wall;

a pumping case having a pump inlet positioned below the surface of the liquid, a pump outlet positioned at the fan wheel space, an impeller positioned in the pump inlet and attached to a shaft and a motor to rotate the shaft, to circulate liquid from the reservoir, through the fan wheel space, through the scrubbing space, and back to the reservoir; and

a fan wheel having fan blades, connected to the shaft and positioned in the fan wheel space to receive the liquid and pump the gas through the passage way and to discharge the gas and the liquid tangentially at a high rotational rate in the scrubbing space, to rotate the liquid with the gas, to impact and centrifugally mix the particulate and the gas molecules with the liquid to scrub the gas.

48. The scrubber of claim 47, wherein the shaft extends up into the cyclone space and has a second fan wheel attached thereto to increase a rate of flow through the scrubber and to increase a rotational rate of gas in the cyclone space.

49. The scrubber of claim 47, wherein the scrubbing cylinder outlet has an outlet rim that is flared and provided with slots to centrifugally direct the liquid flowing through the scrubbing space to flow downward in a rotational manner and to impact the surface of the liquid.

50. The scrubber of claim 47, wherein the motor is mounted in the inlet cylinder.

51. The scrubber of claim 47, wherein the motor is mounted below the bottom wall of the container and the shaft extends up from the motor through a seal in the bottom wall.

52. The scrubber of claim 47, wherein the fan blades of the fan wheel have extensions that extend down into the scrubbing space.

53. The scrubber of claim 1, further comprising a plate positioned below the open bottom end of the scrubbing cylinder to prevent the surface of the liquid from developing an undesirable harmonic oscillation.

54. The scrubber of claim 1, further comprising a refrigerant coil and means to cool the refrigerant coil, positioned in the reservoir of the container.

55. The scrubber of claim 1, further comprising means for circulating a stream of the liquid from the reservoir over a cooled coil and back to the reservoir.